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Exploring the attitudes of secondary school chemistry trainee teachers

Mary Linington
University of East London, UK

Abstract

This article reports the first part of the research done to explore the attitudes of graduate scientists involved in a UK government initiative to increase the number of chemistry teachers in secondary schools in England and Wales. The graduates were training to be chemistry teachers at the University of East London (UEL). The work uses two well-documented instruments to explore the attitudes of trainees to the subject of chemistry and chemists. It compares and analyses results; the work was done with a small number of trainee teachers over several years. It highlights some issues and inconsistencies in the attitudes of graduates through a possible mismatch between the instruments.

Keywords: Attitudes to chemistry; initial teacher training

Background

In England the government funded an initiative, Subject Knowledge Enhancement (SKE), through the Teaching Agency (previously the Training and Development Agency) to recruit and train science graduates and enable them to become specialist chemistry teachers. The students on the SKE course were prospective trainee teachers; successful completion was a requirement for entry to initial teacher training. The courses taught chemistry subject knowledge, not pedagogy, and were of varying length – from 4 to 28 weeks.

The aim of the initiative was to improve the quality of chemistry teaching in secondary schools in England and Wales, through providing a larger pool of qualified chemistry teachers, as secondary schools move to teach separate sciences to 16+. Part of the reason for teaching separate sciences is to increase the number of students studying them to at least 18+. The term 'chemophobia' has been used (IUPAC 2007) to acknowledge an irrational fear of chemicals and chemistry, and there are many, including some trainee teachers, who may have stereotypical views of chemistry. For example, regarding chemicals as the cause of environmental pollution. Furthermore, research on the early stages of career development in chemistry (Zinberg 1976) has outlined several worrying issues. For example, there is clear indication that those chemistry students with lower-level qualifications have poorer attitudes to chemistry. If the SKE initiative is to ultimately encourage young people to study chemistry then the attitudes of those teaching the subject will be critical to the success of the initiative. If teachers have a negative attitude to chemistry then this may be passed on to young people, thus undermining the ultimate aim of the initiative.

This background made me question whether what we are doing with the SKE – giving instruction in subject knowledge to other science or non-chemistry graduates – might be self-defeating. Will there be an increase in the number of students taking separate sciences to at least 18+, if teacher attitudes are negative? So the initial question is clear: Do SKE students (trainee teachers) have a negative attitude towards chemistry?

Literature review

This work builds on previous research done on the attitudes of teachers, trainee teachers, undergraduate and secondary school students, to investigate the attitudes of prospective trainee teachers on the SKE course taught at UEL, over the period 2007 to 2014. For over 40 years and across many countries, there has been significant

research into attitudes to chemistry and its teaching and learning. This has focused on teachers' and trainee teachers' attitudes to pedagogy, some of which has been specifically directed at the training of teachers of chemistry (Kahveci 2009); teachers' and trainee teachers' misconceptions of chemistry and its concepts (Kind 2004); and the attitudes of university and school students to chemistry (Coll et al 2002). Little has been reported on the attitudes of trainee chemistry teachers. In general, attitudes towards chemistry are polarised either positively or negatively: either chemistry is the cause of environmental pollution or the solution to a range of problems such as illness and hunger (Hilbing and Barke 2000).

Methodology

The data collection had two aspects:

1. Survey data

A survey was used to collect data from prospective trainee teachers on the SKE courses at UEL over a period of five years. The survey was modelled on that reported by Coll et al (2002), but extended to explore some personal experiences of learning chemistry, and prospective trainee teachers' attitudes to chemistry and its teaching. Coll et al (2002) reported the design and use of a questionnaire to investigate the attitudes of students to chemistry. They commented that an 'examination of the literature indicated that to understand students' attitude towards chemistry, chemistry self-efficacy and perceptions of their learning experiences, it would be necessary to develop a new instrument'. They defined clearly what is meant by chemistry, attitude-towards-chemistry and chemistry self-efficacy. They designed and tested a new questionnaire, reported it 'possessed both high predictive and concurrent validity' and suggested that the questionnaires would be 'a useful probe for tertiary chemistry teachers that wish to investigate first year chemistry students' learning experiences'.

This work uses their questionnaire for measuring the attitude-toward-chemistry which contains a total of 21 questions to assess: attitude toward chemists, skills of chemists, attitude toward chemistry in society, leisure interest in chemistry, and career interest in chemistry. The self-efficacy scale contains 17 questions. The learning experiences scale, consisting of 31 questions, with four subscales – demonstrator learning experiences (relating to graduate assistants who supervise practical classes), laboratory class learning experiences, lecture learning experiences and tutorial learning experiences – was not used.

The research instrument has been used to investigate the attitude to chemistry of high school students in the USA (Banya 2005).

2. Trainees were asked to 'draw a picture of a scientist'

This Draw-A-Scientist Test (DAST) was first used as an open-ended test designed to investigate children's perceptions of a scientist. Mead & Métraux (1957) was reputedly the first attempt to analyse systematically the drawing of a scientist.

The activity was used within Inner London Education Authority Science Centres in 1975 to explore and influence teachers' attitudes to girls and science (ILEA 1978). There is now significant literature on the test and a published extensive review. Finson (2002) wrote in detail about the DAST and its history. Chambers (1983) covers the history of images of scientists and used the DAST over 11 years to investigate the changes in perception of children as they mature, developing a system to analyse drawings, and a similar but edited system is used here. Trainees were asked to specifically draw a chemist.

The questionnaires and DASTs were administered at the start of the courses, and participation was voluntary. The majority of the prospective trainee teachers completed either the DAST or the survey – a number completed both. Only three sets of results are discussed here.

Sample

In total, six cohorts of pre-service teachers (cohort size varied from 7 to 20) were asked to complete the instruments; not all responded to the survey and the DAST. Trainees ranged in age from 21 to 50+, were of both genders but predominantly female, came from a range of socio-economic backgrounds and were drawn from across ethnic groups. Educational backgrounds

varied significantly, from doctorate-level science qualifications to undergraduate degrees with a significant element of science content, though two trainees had degrees in non-science subjects. The results published here are based on the completed returns of the first three cohorts; for cohort 1, n=3, for cohort 2, n=8 and for cohort 3, n=13. For only the one cohort of 13 trainees was it possible to meaningfully compare and explore the outcomes of the DAST with those of the survey. Further work will be done on this and to explore influences of gender and age across all cohorts.

Overview of results

This work has been undertaken over a period of years and this has enabled the work to be become more focused. Initial results are presented here. A small group of students were involved in the initial course. Only three responded to the data requests, one male and two female. One drew a DAST and the result is printed here, as figure 1, which clearly shows stereotypical elements.

Figure 1: Result of a DAST.

For the survey they were asked to respond on a five-point scale to describe chemists as either athletic or unfit.

Table 1: Chemists' attitudes, from Coll et al. (2002)

Athletic	or	Unfit
Socially aware		Socially unaware
Environmentally aware		Environmentally unaware
Flexible in their ideas		Fixed in their ideas
Care about effects of their results		Only care about their results
Imaginative		Unimaginative
Friendly		Unfriendly
Inquisitive		Indifferent
Patient		Impatient

The Trainees' view of chemists from the questionnaire was very positive. They were overwhelmingly regarded as environmentally aware, inquisitive and patient, flexible in their ideas and caring about the effects of their results. The responses were ordered and are presented in figure 2.

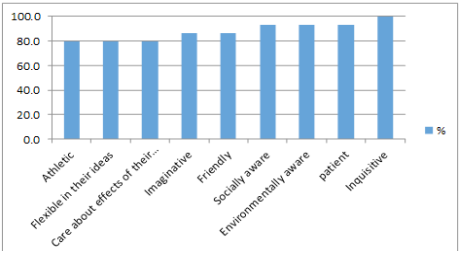

Figure 2: Trainee teachers' views of chemists, rank-ordered. Cohort 1.

Trainees were also asked their views of chemistry as a school subject, specifically:

- Is doing chemistry experiments in school fun?
- Is chemistry one of the most important subjects for people to study?
- Should chemistry be taught separately in secondary schools?

Without exception trainees saw chemistry experiments in school as fun and chemistry as one of the most important subjects for people to study, with two-thirds believing that chemistry should be taught separately in schools.

Why therefore did the DAST drawn by a survey respondent show the stereotypical picture of a man, with strange glasses, triangular mouth, long ear lobes and hair that stood on end, and holding a test tube?

The following year a larger cohort of trainees was involved in the course and a better response was obtained. Nine trainees answered the questionnaire, a response rate of 60%.

The DAST was not used, as previous response had been limited. However, more aspects of trainees' views of chemists were explored through the use of statements from Coll et al (2002). Again the results were rank-ordered, as in figure 3.This showed trainees still overwhelmingly believed that chemistry was an important subject to study and chemists showed attitudes that were positive.

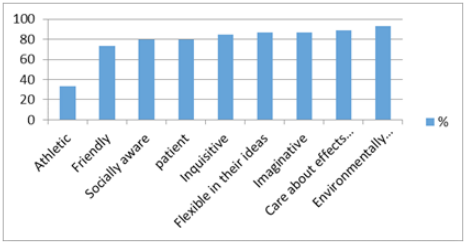

Figure 3: Trainee teachers' views of chemists, rank-ordered by percentage. Cohort 2.

Trainees were asked what they thought about chemistry, against a series of statements (see table 2). They were asked to say whether they strongly agreed/agreed/did not know/disagreed/strongly disagreed with the statements.

Table 2: Statements about chemistry to be graded on a five-point scale.

I think chemistry
Is responsible for global warming
Can solve the problem of global warming
Is about making new chemicals
Is about testing chemicals
Is about cooking
Is all around me
Is done by a chemist
Should be taught separately in schools
Is dangerous
Can be useful
Can be harmful
Is about whizzes and bangs!
Is an important part of the school curriculum
Needs to be understood by all
Can feed the world

The replies, again rank-ordered, showed (figure 4) that highest-scoring (on a five-point scale) was harmful to the environment, and lowest-scoring, at below 50%, was 'done by a chemist'.

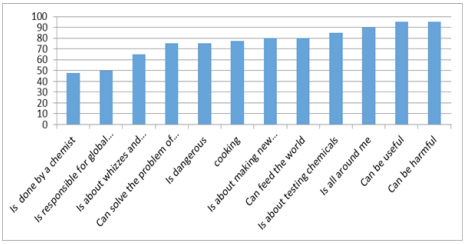

Figure 4: Responses to statements about what trainees think chemistry is, rank-ordered by percentage. Cohort 2.

But still over 75% thought chemistry was important enough to be taught separately in schools and over 85% thought it was an important part of the school curriculum (figure 5).

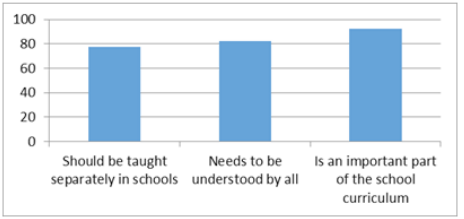

Figure 5: Responses to the statement 'chemistry should', rank-ordered by percentage. Cohort 2.

For this cohort, as previously, attitudes to chemistry seem balanced; so maybe the previous DAST result was an aberration.

To explore this, a third cohort of trainees were asked specifically to complete both DAST and survey instruments. This was the largest course cohort to date: n=20. Although only 13 completed the DAST and survey, a matching of DAST and survey results was attempted.

The test was graded, following Chambers (1983), for:

- pen/paper/notes (symbols of knowledge in Chambers terms)
- test tube (specifically identified with chemistry)
- Bunsen
- flask (specifically identified with chemistry)
- health and safety equipment
- hair
- equipment (Chambers marked for symbols of research – any laboratory equipment)
- glasses
- lab coat.

It is noticeable that, in figure 6, though numbers are small there is still a bias towards drawing a chemist as male, even though there were more females in the group.

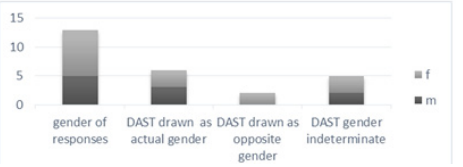

Figure 6: A gender analysis of DASTs. Cohort 3.

Only four trainees made any attempt to draw chemists as 'ordinary' persons; seven went out of their way to draw extreme or stylised and stereotypical pictures. One used a 'stick' drawing and included words such as 'thinking' to give the widest interpretation. Overall the drawings showed several common key characteristics. Again these have been rank-ordered in figure 7.

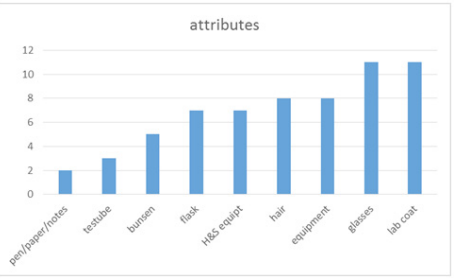

Figure 7: Characteristics of DAST drawings, rank ordered by number of responses. Cohort 3.

Samples of the DAST pictures drawn by cohort 3 are presented here as figures 8 to 11.

Figure 8

Figure 9

Figure 10

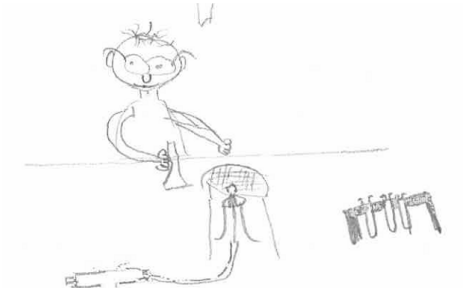

Figure 11

As before, when trainees were asked about chemistry and chemists, through the survey, the answers given are more rational. Trainees were asked to say what they thought chemists are, through grading between two alternatives, as previously.

The results, ordered, as in figure 12, show cohort 3 thinks of chemists as caring more about their results and not being so socially aware.

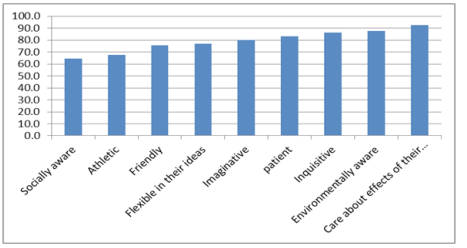

Figure 12: Trainee teachers' views of chemists, rank-ordered by percentage. Cohort 3.

Cohort 3 were asked about chemistry jobs, again using a five-point scale to grade statements, as in table 3.

Table 3: Chemistry job statements. Cohort 3.

Challenging	or	Easy
Varied		Repetitive
Interesting		Boring
Satisfying		Unsatisfying
Exciting		Tedious

Cohort 3 trainees were asked about chemistry jobs and careers. Chemistry jobs and being a chemist are seen as always challenging, never boring and often exciting and varied (figure 13). This could be important as chemistry teachers are often considered the first point of careers advice.

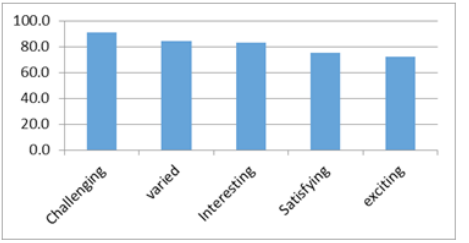

Figure 13: Trainees' views of chemistry jobs, rank-ordered by percentage.

Discussion

Getting secondary students to study physical

science subjects to 18+ in England has been a significant challenge. In this context, the attitudes of trainee teachers to the subject they intend to teach are a key attribute: successful teachers need to be enthusiastic about their subject. When asked to draw a chemist, stereotypical images are drawn by most trainees in this research, concurring with Mead & Métraux (1957), who concluded that the stereotypical images of scientists found in the DAST are also shared by adults training to be teachers .

After the stereotypical DAST drawing of the first, albeit a small, cohort it was felt important to include learning activities that could positively influence trainees' view of chemistry. So the SKE course has two specific units of work that are intended to explore and develop the attitudes of prospective trainee teachers to chemistry. One unit (21st Century Chemistry) starts by looking at what chemistry has done for the world, before moving into a study of recent developments in chemistry. It uses simulation, discussion, practical and research-based work to involve trainees in thinking about chemistry and its impact. The other, Communicating Chemistry, considers chemistry as reported by the current press, 'chemophobia' and then involves students researching and reporting on chemical topics of interest to them. Although neither unit is sold to prospective trainee teachers as having the aim of developing positive attitudes to chemistry, this is a major aim of the work. This research has been used, in part, to evaluate these elements of the chemistry SKE programme.

The DAST instrument continues to give results that do not match the survey results. It is unclear whether this is because the DAST is not suitable for this type of work, or whether the answers to the questionnaire given by trainees are those they think are expected of them. More work needs to be done to explore the relationship, if any, between the task of drawing a chemist and attitudes to chemistry.

Conclusions and further work

When asked to draw a chemist, most trainees draw stereotypical images – the reason why needs to be explored, offering further opportunities for investigation. The validity of the DAST as a measuring instrument in this context needs to be explored; its use to point out stereotypes may be more valid. More work needs to be done to explore the relationship, if any, between the task of drawing a chemist and attitudes to chemistry. Further research work should be done to check responses to survey questions, perhaps by adding a further bank of questions and cross-referencing results. This cross-referencing of attitudes should be explored through interviews with individual trainees. As cohort data increases, a further and continued analysis of the data collected should be done, including an analysis by gender.

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Contact: m.linington@uel.ac.uk